



# Human Factors Vehicle Displacement Analysis: Engineering In Motion

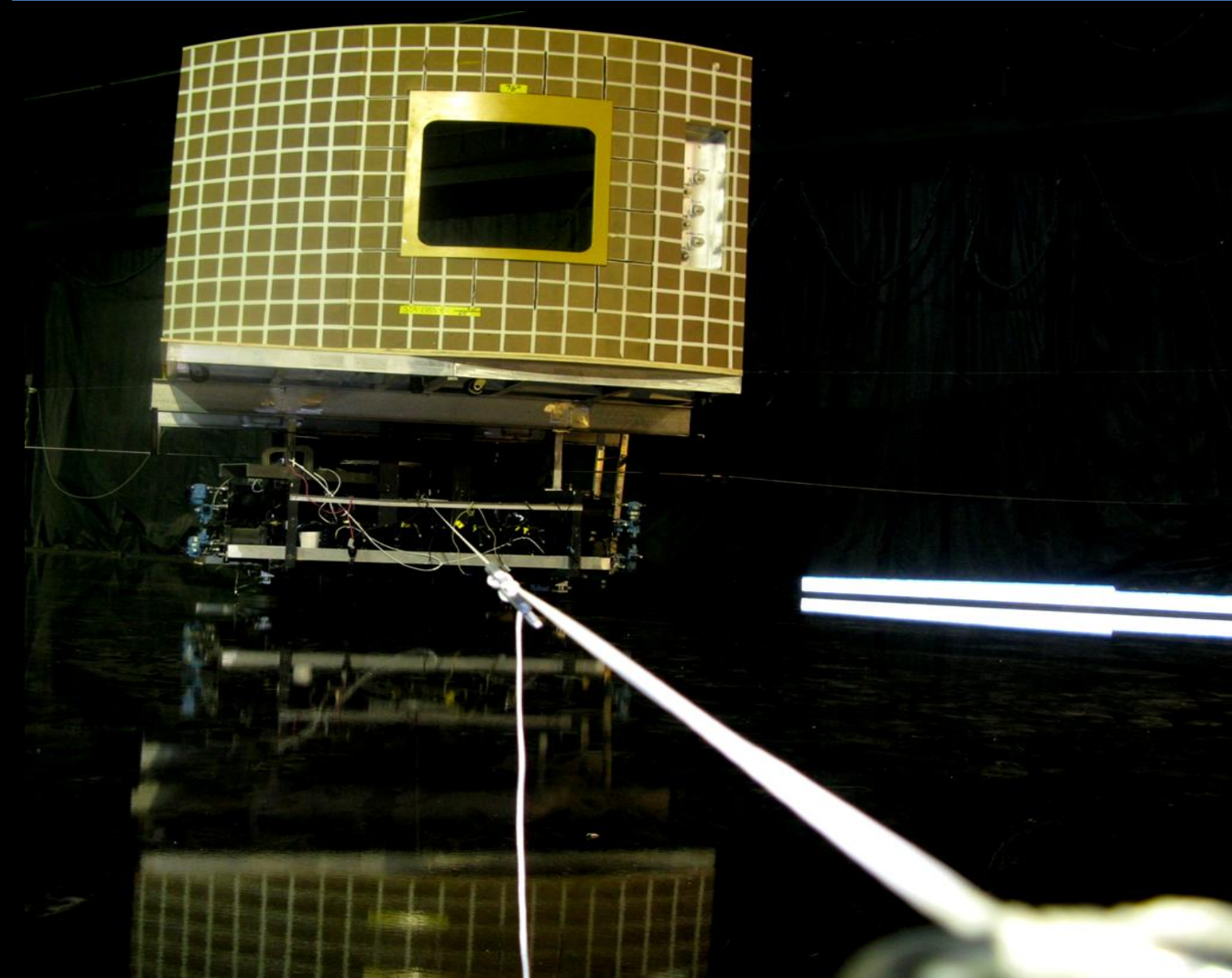


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## I. INTRODUCTION

- While positioned on the launch pad at the Kennedy Space Center, tall stacked launch vehicles are exposed to the natural environment. Varying directional winds and vortex shedding causes the vehicle to sway in an oscillating motion.



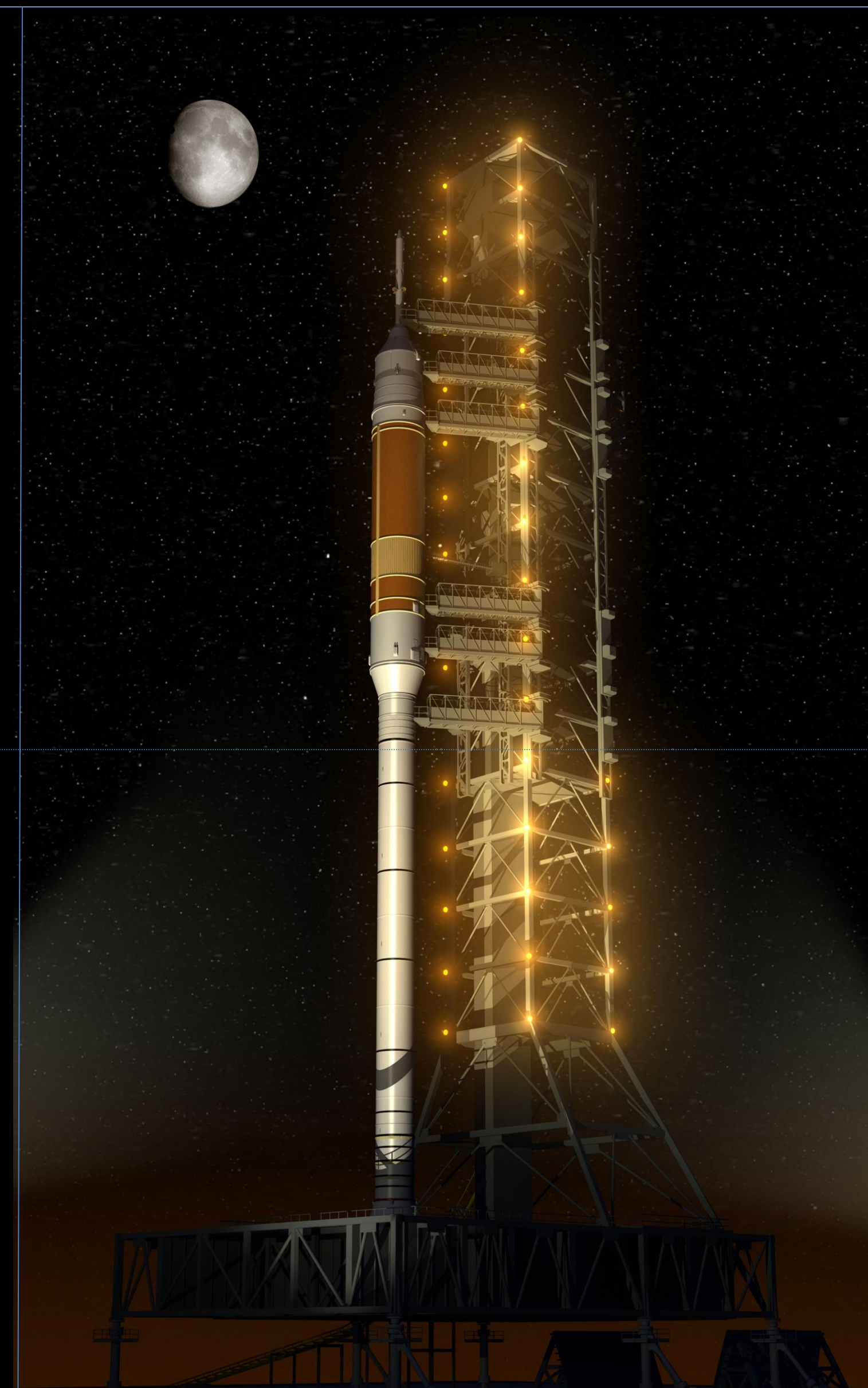
## II. RESEARCH FOCUS

### PURPOSE

- The Human Factors team recognizes that vehicle sway may hinder ground crew operation, impact the ground system designs, and ultimately affect launch availability.

### OBJECTIVES

- Physically simulate predicted oscillation envelopes identified by analysis.
- Conduct a Human Factors Analysis to assess the ability to carry out essential Upper Stage (US) ground operator tasks based on predicted vehicle motion.



## IV. CONFIGURATIONS

### LOCATION

- The MSFC Flight Robotics Laboratory is the largest Precision Epoxy Flat Floor in the world. The floor is laid within one thousandth of an inch to the earth's curvature allowing the 3,500 lb Large Mobility Platform (LMP) to simulate zero G motion in three degrees of freedom.

### HARDWARE

- The LMP floats three thousandths of an inch above the Flat Floor on cushions of air that are supplied by three air-bearings.
- A 72" wall segment represents elevations at the IU and IS, and is mounted on top of the aluminum LMP.
- A stationary scaffolding mockup extends over the Flat Floor to represent the Vehicle Access Arm (VAA).
- The LMP is propelled in an oscillating motion. To simulate the vehicle's sway, diagonal tether lines were threaded through two custom pulleys mounted to rotary servo motors.



## III. METHODOLOGY

- Developed and coordinated a specific project timeline between two MSFC branches: EV82 Human Factors and ES32 Flight Robotics Laboratory.
- Recruited participants and distributed job responsibilities.
- Compiled reference materials.
- Identified ten IU (Instrument Unit) and IS (Interstage) maintenance and ground support operation tasks used in the assessment
- Defined task procedures and created human factors analysis observation sheet
- Designed a full scale part-task layout to simulate planned IU and IS tasks



### PROGRAMMING

- Both rotary servo motors are controlled by a programmable Galil logic controller.
- Two MATLAB programs for the Galil logic control were developed to create delayed alternating sinusoidal graphs that resulted in the desired oscillation.

## V. MOTION DATA

### MATLAB PROGRAM 1

- The program allowed real-time adjustments to the LMP motor speeds.
- Results: A failed machine communication caused an erratic vehicle motion and the emergency breaks to malfunction.

### MATLAB PROGRAM 2

- The program contained predetermined variable inputs.
- Results: The LMP exhibited consistent motion with an undesired oscillation due to vehicle torque and an unidentified center of gravity.

## VI. FUTURE WORK

- Conduct more in-depth assessments.
- Perform planned tasks, which include the removal of Line Replacement Units (LRU), installation of Ground Support Equipment (GSE), and loading of propellants as the LMP oscillates.
- Submit Human Factors Analysis Report as reference material for future stacked launch vehicle designs.



## REFERENCES

- Preliminary Report (DCI\_TM\_012309-1047-02), and timeline history MATLAB data files
- Functional Objective Task Sheets
- Prior Human Factor Analysis Reports

## THANK YOU

- Dr. Steve Hahn, DCI
- Charlie Cox, MSFC Repository
- Tom Bryan, ES32
- Ricky Howard, ES32
- Thomas Dematteis, ES32
- Charles Cowen, ET20
- Thomas Perrin, EV91
- Allen Taylor, EO40
- Don Krupp, EV82
- Charlie Dischinger, EV82
- John Smith, EV82
- David Reynolds, EV82
- Clay Robertson, EV82
- Chris Daniels, EV82
- Richard Howard, EV82
- Sally Richardson, EV82

